

Current Trends in Adaptive Training With Military Applications: An Introduction

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The U.S. military's operational and institutional training requirements continue to increase in scope and complexity; but training resources, including time, manpower, and money, are limited. Many of the solutions the military has proposed to meet these challenges depend heavily on adaptive training. The purpose of this special issue is to examine current trends in adaptive training, with a particular attention to the military environment. This article summarizes contemporary approaches and challenges to implementing adaptive training and provides an overview of the articles included in the special issue.

Today's U.S. military faces a substantial challenge when it comes to training modernization. On the one hand, the military training communities share a goal of modernizing training development and delivery to meet the educational needs of a new generation of "digital learners." On the other hand, impending reductions to military training budgets make implementing technology-based solutions to provide engaging, personalized training to warfighters a daunting task. The challenge to the military training community is to do more with less. An example of how military leadership is attacking this problem has

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been described by the Army's Training and Doctrine Command (TRADOC) in their *U.S. Army Learning Concept for 2015* (known as ALC 2015; TRADOC, 2011). This visionary concept calls for a reduction in instructor-led training, and a transformation of lecture-based classes into collaborative problem-solving exercises. It also calls for technology-based instruction and training to be blended into institutional, operational, and self-development training, and for training experiences to be tailored to each individual's experience, competence, and need, without sacrificing standards.

One means of sustainably implementing the types of changes the Army is envisioning in the ALC 2015 is adaptive training. Adaptive training refers to instruction that changes dynamically based on the learners' performance, abilities, learning needs, experiences, skills, and other individual differences (Park & Lee, 2004; Shute & Zapata-Rivera, 2008; Vanderwaetere, Desmet, & Clarebout, 2011). In theory, adaptive training should contribute to more efficient and effective military training because it provides flexibility to meet individual needs. However, the phrase "adaptive training" can describe a broad range of techniques and technologies used to personalize training, ranging from lower levels of adaptation (i.e., ability grouping, group problem solving, and training placement guided by pretest scores) to more sophisticated uses of artificial intelligence that provide adaptive technology-based instruction (i.e., intelligent tutors). While the benefits of one-on-one human tutoring are well documented (Bloom, 1984), the question of how adaptive training should be implemented with computer-based tutors and in the classroom still demands attention from researchers. The purpose of this special issue of *Military Psychology* is to examine adaptive training as it pertains to military training. Our goal is to provide insight on the types of research that academic, government, and industry labs are conducting to address the military's need to provide adaptive training. We also sought to clarify best practices on how and when to adapt training and highlight areas where more research is needed to advance adaptive training theory, research, and practice.

The Spectrum of Adaptation Training

The U.S. military is faced with the unique challenge of training thousands of individuals with diverse backgrounds to uniformly high standards of performance under extremely tight financial, resource, and time constraints (McCarthy, 2008). Each Soldier, Sailor, Marine, and Airman brings a unique set of characteristics and experiences to the classroom. They have different task proficiencies inside and outside their mission roles, different operational and leadership experiences, and different sustainment skills. Thus, a "one-size-fits-all" approach to training may be ineffective and inefficient in meeting individual or team training needs in a timely manner. For this reason, and for many other reasons, the military has made adaptive training, and in particular, adaptive training technology, a high priority.

As we previously mentioned, there are a variety of ways to adapt training. If we take the example of a conventional lecture-based classroom as a nonadaptive approach, the teacher could split the class into groups, with each group receiving content or assignments that fit their ability level; the teacher could survey the class's knowledge using a pretest and mold the lectures and assignments to the students' points of need; the teacher could use a mastery learning strategy in which students are allowed to work at their own pace, moving from one assignment to the next only when they demonstrate mastery of the assignment; or the teacher could use peer-tutors to approximate the benefits of one-on-one tutoring. Strategies analogous to these could be applied to technology-based training as well. For example, students could receive different versions of training content (i.e., be placed into different training tracks) based on an assessment of incoming knowledge or ability level, students could advance through modules at different paces based on how fast they demonstrate mastery, or students could be paired with an intelligent tutor to help them work through problems.

These approaches, and adaptive training approaches in general, range on a spectrum from lower levels of adaptation that qualify as *macro-adaptive* strategies to more sophisticated types of *micro-adaptive* training that use assessment of ongoing student performance to determine what, when, and how to adapt. With macro-adaptive training, each student is presented with an instructional curriculum that is unique to the group to which they are assigned (McCarthy, 2008, Randi & Corno, 2005). Students are placed into groups based on formal assessments (i.e., tests of prior knowledge or general ability), and curriculums are preplanned to fit the strengths and weaknesses of the group. These adaptations could manifest in different *versions* of training that differ according to the breadth or depth of content, difficulty of content, sequencing of content, instructional media, or some other pedagogical intervention (e.g., feedback strategy, number of practice problems, etc.). A key feature of macro-adaptation is that the adaptive interventions are preplanned; the decision about *what* to adapt and *how* to adapt are locked in place before instruction begins. Early on, macro-level adaptations were applied to classroom instruction to approximate the benefits of tailored instruction (Reiser, 1987), but more recently, they have been used in conjunction with technology-based training (McCarthy, 2008; Shute, 1993). One of the benefits of macro-adaptive training is that these techniques are not as resource-intensive or costly to implement as techniques on the higher end of the spectrum (Shute & Towle, 2003). Moreover, they can be fairly effective (Argys, Rees, & Brewer, 1996; Shute, 1993).

Contrary to macro-adaptive training, micro-adaptive training adjusts instructional content in real time based on continuous assessments of student performance. Students may receive different feedback, prompts, hints, or pedagogical strategies based on response errors, response latencies, or emotional states during training (Park & Lee, 2004; Woolf, 2009). An example of micro-adaptive

instruction is human tutoring, which is on the highest end of the adaptive spectrum. The tutor selects the most appropriate information and tutoring method for the student based on his or her judgment of the student's learning needs and abilities. In technology-based training, micro-adaptive strategy can be found in any system that adapts the sequence of content, the instructional strategy, or the learning trajectory according to real-time performance of the student. For example, intelligent tutoring systems (ITS), which use artificial intelligence to provide customized instruction, feedback, and support to students, provide a customized training experience by diagnosing student performance and prescribing instructional interventions that target the strengths or weaknesses of the student.

Micro-adaptive training is most receptive to student needs; however, it is costly to implement (Park & Lee, 2004). One-on-one human tutoring is impractical or even impossible in most military settings. When applied to technology-based training, the complexity of providing micro-adaptive training software requires a system that is able to automatically assess student aptitude, diagnose strengths and weaknesses, and adapt coaching (e.g., feedback, hints) to student performance as they learn. This can only be accomplished through the coordination of a number of tasks normally performed by humans, including: assessment of complex performance; comparison of student performance to a desired level of mastery (e.g., student and expert models); the translation of performance data into personalized coaching; the selection of tutoring methods; and the adaptation of coaching strategies as students learn. Implementing these activities through computer-based adaptive training is resource-intensive and requires expertise from a variety of domains including instructional design, artificial intelligence, human-computer interaction, and the learning sciences.

State of the Evidence

Reviews of the adaptive training literature suggest that, while there is some evidence that adaptive software systems lead to learning (VanLehn, 2011), and one-one-tutoring techniques can be translated into group settings (e.g., macro-adaptations, Randi and Corno, 2005), guidelines for *what* and *when* to adapt, and the relative effectiveness of different adaptive interventions are lacking. For example, in their review of the literature, Durlach and Ray (2011) found that out of 181 papers that addressed technology-based adaptive instruction procedures, only 17 papers directly compared an adaptive system to a nonadaptive system or one adaptive method to another. Many of the experiments used multiple adaptive techniques together, making it difficult to determine the relative contribution of the different types of adaptive interventions. Consequently, the authors were unable to determine which adaptive techniques might be more effective than others. There is also a lack of guidance for *how* to adapt. The military recognizes that lower levels of adaptation (i.e., using pretests to guide placement in programs of instruction)

will also play a significant role in future training. Depending on the objective of training, tailored training and macro-based adaptation strategies could be equally as effective as advanced levels of adaptation. Therefore, determining when and how much adaptation is needed in order to reap the most benefits requires consideration. Given the call for future military training to use the spectrum of adaptive training to deliver tailored coaching, tutoring, and feedback, and the increasing role technology is playing in military training, the topic of adaptive training is a timely topic, and one that needs more attention by researchers.

OVERVIEW OF ARTICLES IN SPECIAL ISSUE ON ADAPTIVE TRAINING WITH MILITARY APPLICATIONS

This special issue represents one step toward developing a better understanding of the state of the literature with regard to adaptive training in military applications, and with the aim of providing guidance to the U.S. military. We invited authors to submit empirical articles that examined the effectiveness of adaptive training approaches and methodologies, applied articles that shared lessons learned in the development and application of adaptive training in the classroom or technology-based applications, review papers that summarized the benefits of adaptive training technologies or methodologies, and papers that summarized the state of the art in adaptive training. We attempted to provide the reader with papers that span the entire adaptive spectrum—that is, papers that depict how low-end adaptive strategies can be applied to face-to-face training, and papers that describe more sophisticated examples of adaptive instruction applied to technology-based training, particularly with simulations and game-based training technology.

We admit that our sample of articles is limited; this special issue only contains six articles, and it includes a limited amount of empirical data on adaptive training. The limited amount of empirical data on adaptive training speaks to the need for current and future efforts to push the science forward and develop basic guidelines for developing adaptive training that are rooted in empirical data. Despite these limitations, we feel strongly that these papers adequately highlight the types of research academic, industry, and government institutions are conducting in order to better understand how military instructors are adapting training, how adaptive training is being incorporated into technology-based training, and where further empirical research is needed.

The first paper in our special issue is a literature review of the adaptive training systems literature by Landsberg and her colleagues. This review is timely given the U.S. military's increasing interest in leveraging adaptive training systems to increase training effectiveness while facing looming budget cuts. The authors describe different approaches to developing adaptive training systems, including micro-adaptive, macro-adaptive, and hybrid techniques. They then discuss

considerations for adaptive training, including the different types of variables to consider as the basis of adaptation and the specific types of adaptive interventions that can be used. A discussion of potential areas for future research follows, with the authors identifying a lack of conclusive data about the variables that should be used to adapt, the predictive power of these variables, and other critical aspects of adaptive training. It is clear from their review that prior to the widespread implementation of adaptive training systems in the military, much research has yet to be done to determine how and when this approach should be used.

In our next three papers, the authors provide examples of the types of adaptive training research called for by Landsberg and colleagues. Billings describes research investigating the role of different types of feedback on participant learning within an adaptive training system. In order to examine the effectiveness of adaptive feedback, the author compared student performance in a simulated search and rescue task when provided different types of feedback. Participants received one of the following types of feedback: bottom-up adaptive feedback, top-down adaptive feedback, general (static) feedback, detailed (static) feedback, or no feedback. The results suggest that while detailed (static) feedback was not statistically different than bottom-up adaptive feedback, bottom-up adaptive feedback allowed trainees to perform better more quickly than top-down adaptive feedback. Moreover, results showed that participants learned better when they received either detailed (static) feedback, bottom-up feedback, or top-down feedback, compared to when they received general (static feedback) or no feedback at all. These results suggest that providing adaptive feedback can improve the efficiency of performance acquisition and have direct implications for feedback implementation in simulation-based training and instruction.

Bink and Cage provide an example of how Army training can benefit from the use of adaptive techniques in field instruction. They describe the development of two training aids for a land navigation skill, one addressing the needs of individuals who had difficulty understanding the concepts underlying the skill, and one more tailored to those with a familiarity with the concepts. Once the aids were developed, their effectiveness was evaluated using infantry Soldiers in One Station Unit Training (OSUT). The results of this experiment indicate that while all soldiers benefited from using the training aid designed for the more advanced students, only the low-performing soldiers (as determined by a pretest) showed improvement after using the training aid developed for students who had difficulty with the skill. These findings suggest that it is possible to tailor training aids for hard-to-teach tasks such as land navigation to individual levels of skill. The training aids were combined into a single training tool to address the needs of soldiers of all skill levels.

Bauer, Brusso, and Orvis present empirical research on how personality can moderate the effectiveness of different adaptive instructional conditions. This research resembles macro-adaptive and aptitude treatment interaction (ATI)

research described by Landsberg and her colleagues. Specifically, they examine the interaction of task difficulty (i.e., adaptive difficulty, forced increase of difficulty, and static difficulty), and three personality traits (i.e., neuroticism, conscientiousness, and openness to experience). Findings indicated that personality indeed influenced the effectiveness of the adaptive intervention; individuals higher in openness to experience and neuroticism performed better when difficulty was adapted, while individuals low in these traits performed better with the nontailored difficulty. These findings suggest that certain personality characteristics may moderate the effectiveness of adaptive difficulty.

Reaching the high end of the adaptive training spectrum, Schatz, Oakes, Folsom-Kovarik, and Dolletski-Lazar describe a special case of intelligent tutors, called situated tutors, that combine the benefits of intelligent tutoring systems and simulation-based instructional systems. Their report provides a comprehensive review of situated tutors, documenting 86 such training technologies, half of which directly support military training, and examine their capability to support the acquisition of higher-order cognitive skills. A framework for classifying these systems is provided, along with recommendations for their future development and evaluation.

In our final article, Schaefer and Dyer discuss what adaptive training means to the Army and describe findings from interviews with instructors from 51 Army courses regarding the frequency and types of adaptive techniques used in Army training. They conclude that while adaptive training, as defined in an academic context, is not frequently used in the Army, some tailoring techniques are used by instructors. These include adjusting the course content to match the interests and experiences of the students, working with individuals after class hours, and breaking classes into small groups. The authors then provide recommendations for how adaptive training can work in an Army context, noting that because courses are so varied, making generalizations is difficult. The authors conclude with a list of broader issues that researchers and practitioners must consider when applying adaptive training to Army instruction.

Taken together, the articles presented in this special issue of *Military Psychology* highlight a broad range of research being conducted on adaptive training with regard to military applications. Generally speaking, the findings of these papers suggest that the U.S. military would benefit from increasing the incorporation of adaptive techniques into warfighter training programs. This could involve the use of highly sophisticated, technology-based adaptive training systems, such as described by Schatz and colleagues, or could simply involve increasing instructors' use of tailored training techniques, as discussed by Schaefer and Dyer. Incorporating these techniques into military training would improve warfighter understanding of subject material, decrease warfighter time to train, and save instructor resources. Given the military's need to consolidate resources and maximize efficiency, these training systems and techniques could provide a substantial

benefit. While these papers provide an informative overview of the adaptive training literature, they also raise more questions. It is clear that while adaptive training systems and techniques have been researched and implemented for some time now, there is little clear guidance for the instructor regarding how and when to adapt training. In order to provide this guidance, further research must be conducted. Several articles in this special issue demonstrate the types of research that need to be done to answer these questions. Bauer and colleagues describe research into the interaction of task difficulty and learner characteristics, such as personality traits, in video-game-based adaptive training. Billings investigates the role of feedback in an adaptive training context. While both of these papers provide insight into the roles of these complex variables in adaptive training effectiveness, far more research is needed. It is our hope that this special issue will serve as a call to researchers in both the academic and industry communities to perform these studies, so that the full value of adaptive training to the military can be implemented.

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